

Breakout 5: Computer Architecture

Drive innovation at the frontiers of computer architecture and information technology, preparing the way for ubiquitous adoption of parallel computing, power-efficient systems, and the software and architectures needed for a decade of increased capabilities. Accelerate the development of special-purpose devices that have the potential to change the simulation paradigm for certain science disciplines.

1 - What (in broad brush) is feasible or plausible to accomplish in 5-10 years?

- Accelerate point technologies – RAM, interconnect, storage
- Custom architectures for specific applications spaces – to reduce unneeded costs and accelerate progress compared with business as usual
- Simulate machines before we build them based on application requirements – tune machines before you commit to specific architecture
- Start over in terms of programming models – take 2 applications, one easy one hard, and find way to parallelize it while thinking about the correct architectures
- Identify application areas and user communities for early analysis of requirements
- Gather deeper understanding of application requirements at current scale and exascale
- Build community for early users of exascale
- Understand social dynamics of application programming community (social science)

2 - What are the major challenges in the area?

- Lack of experienced parallel programmers (for HPC)
- From programming model figure out how to identify and exploit locality (just caches and local memory on chip is not sufficient)
- Solve local memory problem – from hardware perspective address memory wall
- We should do some basic research to think about which applications and architecture would be effective at exascale as opposed to just assuming either one is fixed
- System wide challenges: space, power, cooling, I/O, OS
- Fault tolerance is major hurdle. Partially be a social problem, community needs to develop and use fault tolerance tools.
- Build resilience into the applications as well as the hardware and software stack, transactional memory is one example

3 - What is today's state-of-the art in the area ?

- Application developers panic in preparation for petaflop
- Build first program later (select codes after fielding the machine)

4 - How would we accelerate development?

- Find better way to interface with vendors – more iterative vendor collaboration
- Need platforms to conduct what-if hardware experiments (prototyping, RAMP)
 - - Enhance vendor interactions
 - - Explore designs outside of mainstream
- Leverage non-conventional technologies that are not just part of workstation
- Need to train new generation of parallel programmers – DOE needs to have an educational institute to train students on how to use MPPs
- Performance tools that scientist can understand to help parallelize and optimize codes

5 - What are expected outcomes and impact of acceleration or increased investment?

- Develop program to develop and study extreme-scale systems before (and during) the building process (like all large scale experimental devices, such as ITER)
- Develop programming paradigms and architectures synergistically
- Ensure effective platforms and programming models emerge

6 - What scale of investment would be needed to accomplish the outcome?

- How much do you have?
- How much is generally invested in high-end scientific instruments?

7 - What are the major risks?

- Fear of failure – don't be too timid (are we not reaching far enough)
- Building a one off solution that does not profoundly influence future computational science
- Ignore massive industrial investment (failure to leverage mass market technology)
- We can only examine finite number of architectural flavors and application areas, we must figure out the most productive set to explore using preliminary modeling etc
- Failure to properly engage vendors? Can't live in bubble

8 - What and who are we missing

- We said most of this 10 years ago – what did we not learn
- New generation of parallel programming masses (gaming, MS, etc). Many of these programmers will be off-shore.
- Need strong partnerships with academics